3.0 RESULTS AND DISCUSSION

3.1 Geologic Conditions

Four formations outcrop within the study area (Figure 2). Stratigraphic descriptions provided herein were obtained from Doelling (1972), Danielson et al. (1981), and Lines (1985).

The Blackhawk Formation is the principal coal-bearing unit in the region. This formation consists of interbedded layers of sandstone, siltstone, shale, and coal. Although sandstone comprises approximately half of the formation, it is lenticular, with individual beds being traceable for only short distances (Lines, 1985). The Blackhawk is about 1000 feet thick in the coal lease area, with the principal coal seam (the Hiawatha seam) occurring near the bottom of the formation.

The Castlegate Sandstone overlies the Blackhawk Formation and consists of cliff-forming sandstones of fluvial origin. The sandstones are massive and medium to coarse grained. In the area of the coal lease, the Castlegate Sandstone is approximately 200 feet thick.

Overlying the Castlegate Sandstone, the Price River Formation consists predominantly of friable limestones and limy sandstone interbedded with pebbly conglomerates and shales. It forms steep receding slopes and is about 700 feet thick in the coal lease area.

The uppermost formation what outcrops within the study area is the North Horn Formation. This formation mainly consists of limy shale, with interbeds of limestone and sandstone. The North Horn Formation is approximately 1000 feet thick in the coal lease area an serves as a recharge unit to underlying formations as well as supplying water to springs within the formation.

Underlying the Blackhawk Formation and outcropping east of the study area is the Star Point Sandstone. This formation is of significance since it (together with the saturated portions of the Blackhawk Formation) comprises a regional aquifer. The Star Point is a massive sandstone with minor interbeds of shale and siltstone near its base. In the vicinity of the study area, the Star Point Sandstone is 350 to 450 feet thick.

The Joe's Valley Fault along the west edge of East Mountain is the eastern fault boundary of a graben that extends several miles both north and south of the study area (Lines, 1985). Davis

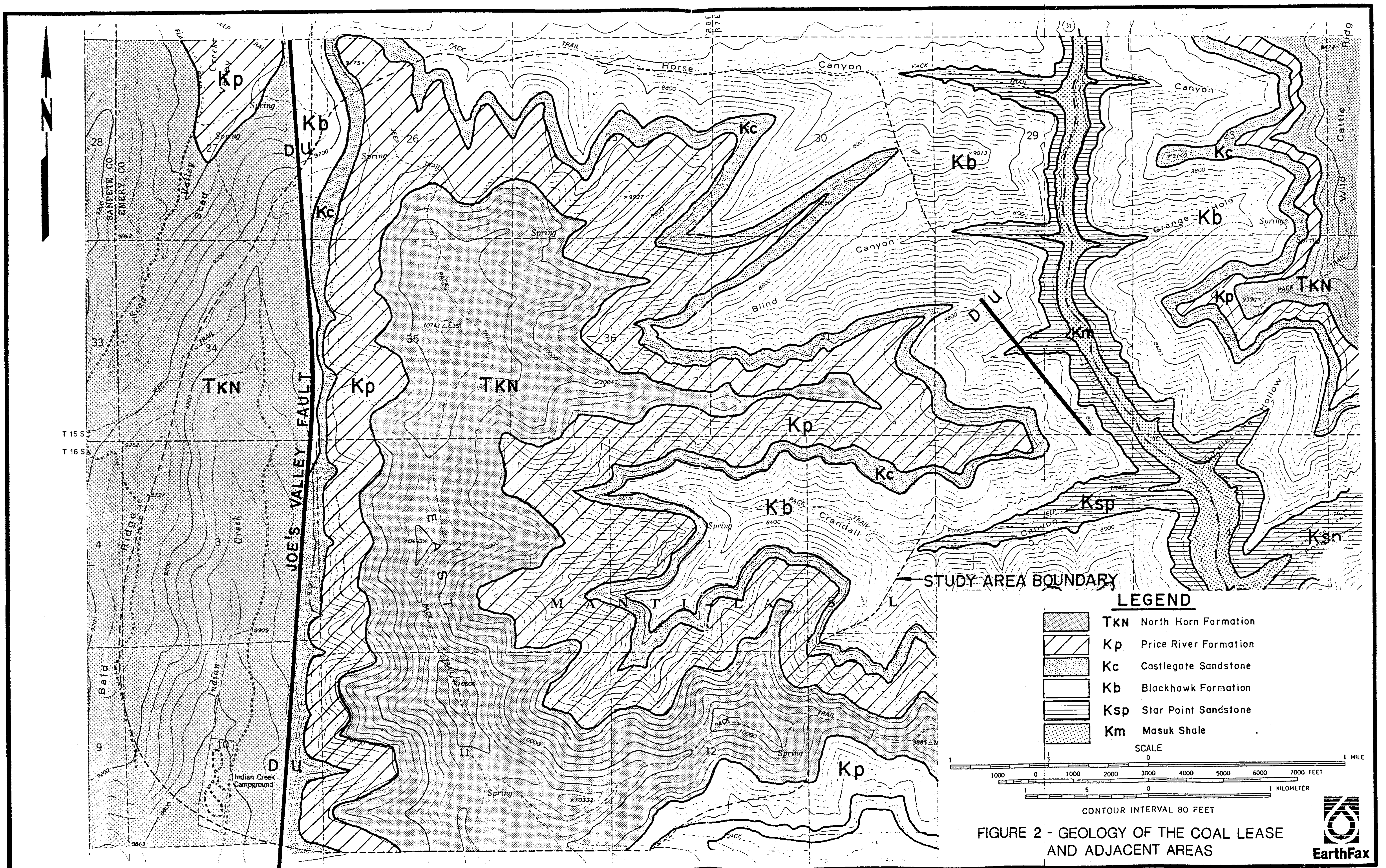

FIGURE 2 - GEOLOGY OF THE COAL LEASE AND ADJACENT AREAS

and Doelling (1977) estimate that the total throw along the fault in this area is about 2300 feet.

3.2 Seepage Occurrence

Locations of the seeps and springs found in the coal lease and adjacent areas are shown on Figure 3. Field data collected during the inventories are contained in Tables 1 (flow conditions and temperature), Tables 2 (pH), Table 3 (specific conductance) and Table 4 (geologic unit and use).

Springs and seeps within the coal lease and adjacent areas tend to be grouped within a given locale while other areas with relatively similar surface conditions are noticeably devoid of springs and seeps. This occurs primarily in response to changes in the structure of the geologic units within each formation or topographic area.

The dip of the bedrock in the vicinity of the coal lease area is approximately one percent to the southeast. Therefore, a significantly higher number of springs are present in Crandall, Blind and Horse Canyons than are present on the west side of East Mountain.

Numerous landslides are visible on the west side of East Mountain. These slides probably occurred during the excessively wet years of 1982 through 1985. It is probable that seeps and springs aided in creating the unstable conditions which lead to the landslides. Since seepage is not now typically evident at the landslides, these seeps and springs were probably destroyed during the movement of the hillslope.

According to Lines (1985), the Blackhawk Formation and the underlying Star Point Sandstone are categorized jointly as an aquifer in the Wasatch Plateau where they are saturated. The degree of saturation generally increases as the amount of overburden increases. Near deeply incised canyons, the aquifer is naturally drained. The Blackhawk-Star Point aquifer yields water to mines in the area.

In areas such as East Mountain where strata that overlie the Blackhawk-Star Point aquifer are several hundred feet above the bottoms of local canyons, aquifers in the overlying strata are perched. This perching occurs where more-permeable strata overlie less-permeable strata (such as sandstones or fractured limestones overlying shale). Perched aquifers are common in the North Horn and Price River Formations (Lines, 1985) where they yield water to springs.

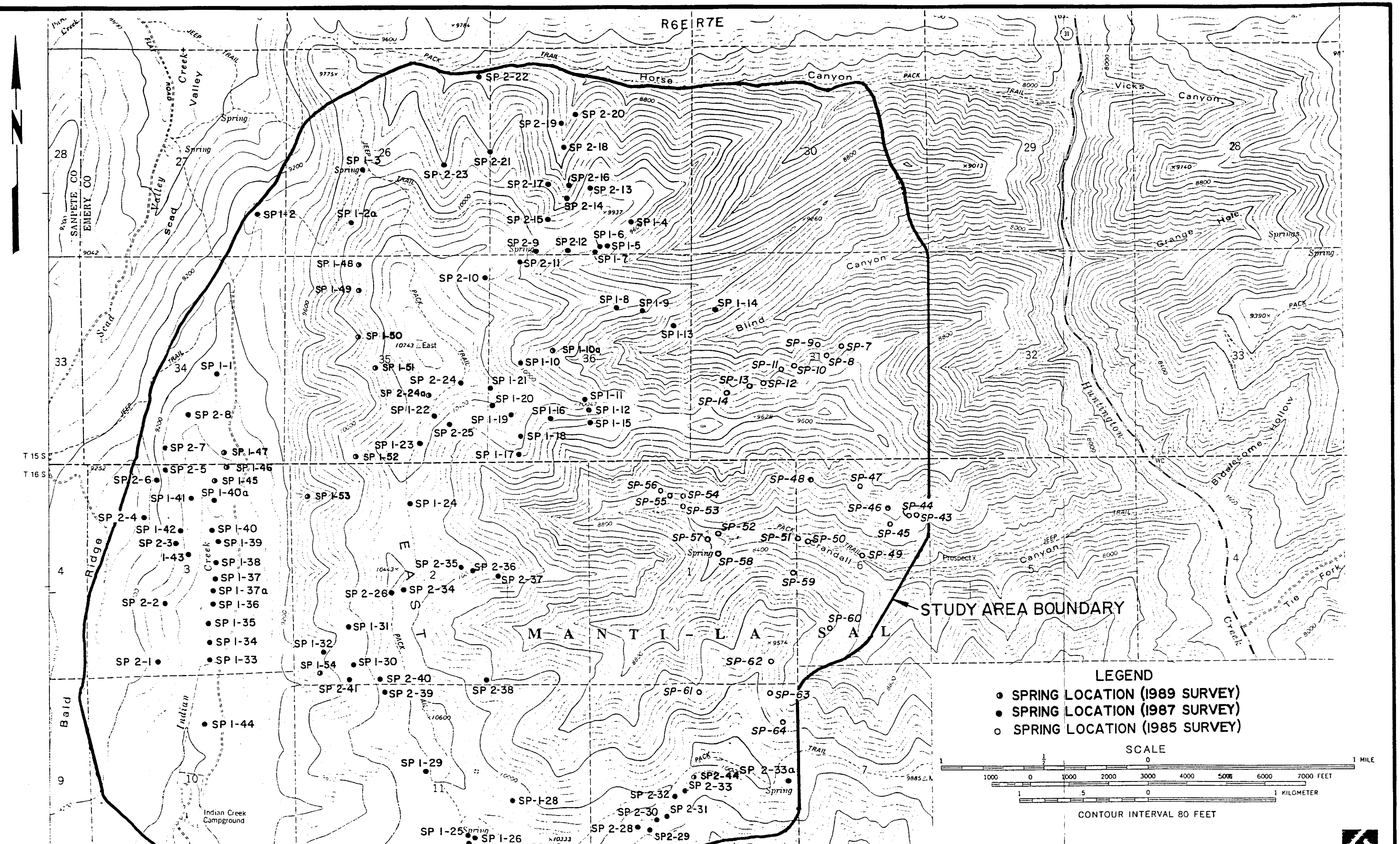

FIGURE 3 - LOCATIONS OF SEEPS AND SPRINGS

Table 1. Results of flow conditions and temperature measurements for the period of June 1985 through October 1989 seep and spring survey in the coal lease and adjacent areas.

Field Number	June 85 Flow (gpm)	June 85 Temp (°C)	Oct. 85 Flow (gpm)	Oct. 85 Temp (°C)	July 87 Flow (gpm)	July 87 Temp (°C)	Oct. 87 Flow (gpm)	Oct. 87 Temp (°C)	Oct. 89 Flow (gpm)	Oct. 89 Temp (°C)
SP-7	10	10.0	Dry	-	-	-	-	-	Dry	-
SP-8	20	3.5	Dry	-	-	-	-	-	Dry	-
SP-9	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-10	40	10.0	Seep	(a)	-	-	-	-	Dry	-
SP-11	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-12	15	3.0	Seep	(a)	-	-	-	-	Dry	-
SP-13	3	7.0	Dry	-	-	-	-	-	Seep	(a)
SP-14	25	5.5	1	6.0	-	-	-	-	1.0	6.0
SP-43	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-44	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-45	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-46	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-47	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-48	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-49	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-50	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-51	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-52	1	12.0	1	7.0	-	-	-	-	<<1	6.7
SP-53	8	5.5	5	5.0	-	-	-	-	Dry	-
SP-54	15	5.5	5	5.5	-	-	-	-	<<1	2.2
SP-55	10	5.5	10	5.5	-	-	-	-	Seep	(a)
SP-56	15	5.5	15	6.5	-	-	-	-	Seep	(a)

Table 1. (continued)

Field Number	June 85 Flow (gpm)	June 85 Temp (°C)	Oct. 85 Flow (gpm)	Oct. 85 Temp (°C)	July 87 Flow (gpm)	July 87 Temp (°C)	Oct. 87 Flow (gpm)	Oct. 87 Temp (°C)	Oct. 89 Flow (gpm)	Oct. 89 Temp (°C)
SP-57	6	5.5	6	4.5	-	-	-	-	Dry	(a)
SP-58	10	5.0	5	9.0	-	-	-	-	4	5.6
SP-59	1	7.0	1	5.0	-	-	-	-	Dry	(a)
SP-60	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-61	15	2.0	1	9.0	-	-	-	-	Dry	-
SP-62	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-63	Seep	(a)	Dry	-	-	-	-	-	Dry	-
SP-64	10	3.0	Dry	-	-	-	-	-	Dry	-
SP1-1	-	-	-	-	<<1	2.9	3	7.0	Seep	(a)
SP1-2	-	-	-	-	2	4.0	Dry	-	Dry	-
SP1-2a	-	-	-	-	5	4.0	1	7.0	.12	2.9
SP1-3	-	-	-	-	<1	2.0	<1	2.0	.25	2.8
SP1-4	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP1-5	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP1-6	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP1-7	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP1-8	-	-	-	-	<<1	11.0	Dry	-	.2	5.6
SP1-9	-	-	-	-	Seep	(a)	Seep	(a)	Seep	(a)
SP1-10	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP1-10a	-	-	-	-	-	-	-	-	(b)	-
SP1-11	-	-	-	-	3	4.0	Dry	-	(b)	-
SP1-12	-	-	-	-	Seep	(a)	Seep	(a)	0.1	3.3
SP1-13	-	-	-	-	Seep	(a)	Seep	(a)	Seep	(a)

Table 1. (continued)

Field Number	June 85 Flow (gpm)	June 85 Temp (°C)	Oct. 85 Flow (gpm)	Oct. 85 Temp (°C)	July 87 Flow (gpm)	July 87 Temp (°C)	Oct. 87 Flow (gpm)	Oct. 87 Temp (°C)	Oct. 89 Flow (gpm)	Oct. 89 Temp (°C)
SP1-14	-	-	-	-	Seep	(a)	Seep	(a)	Seep	(a)
SP1-15	-	-	-	-	<<1	5.0	Dry	-	0.1	2.2
SP1-16	-	-	-	-	<<1	11.0	Dry	-	Dry	-
SP1-17	-	-	-	-	10	5.0	2	4.0	Dry	-
SP1-18	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP1-19	-	-	-	-	<<1	6.0	Dry	-	Dry	-
SP1-20	-	-	-	-	<1	4.0	<1	8.0	(b)	-
SP1-21	-	-	-	-	<1	4.0	Dry	-	(b)	-
SP1-22	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP1-23	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP1-24	-	-	-	-	<1	5.0	Seep	(a)	0.1	3.3
SP1-25	-	-	-	-	3	3.6	3	7.0	0.25	4.4
SP1-26	-	-	-	-	2	3.7	2	7.0	0.5	4.4
SP1-27	-	-	-	-	<1	2.8	Dry	-	0.1	5.0
SP1-28	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP1-29	-	-	-	-	<<1	3.0	Dry	-	Seep	(a)
SP1-30	-	-	-	-	<1	3.1	Dry	-	.25	6.8
SP1-31	-	-	-	-	<1	3.3	Dry	-	Seep	(a)
SP1-31a	-	-	-	-	-	-	-	-	Seep	(a)
SP1-32	-	-	-	-	Seep	(a)	Seep	(a)	-	-
SP1-33	-	-	-	-	Seep	(a)	<1	7.0	.5	5.5

Table 1. (continued)

Field Number	June 85 Flow (gpm)	June 85 Temp (°C)	Oct. 85 Flow (gpm)	Oct. 85 Temp (°C)	July 87 Flow (gpm)	July 87 Temp (°C)	Oct. 87 Flow (gpm)	Oct. 87 Temp (°C)	Oct. 89 Flow (gpm)	Oct. 89 Temp (°C)
SP1-34	-	-	-	-	<<1	4.0	15	8.0	<<1	10.8
SP1-35	-	-	-	-	1	11.0	4	7.0	<<1	14.5
SP1-36	-	-	-	-	<<1	4.0	3	8.0	<<1	9.3
SP1-37	-	-	-	-	Seep	(a)	4	5.0	<<1	5.6
SP1-37a	-	-	-	-	<1	4.2	3	7.0	.5	6.5
SP1-38	-	-	-	-	<<1	4.2	2	7.0	<<1	7.4
SP1-39	-	-	-	-	<1	4.1	3	7.0	<<1	9.0
SP1-40	-	-	-	-	<<1	4.4	10	7.0	.5	6.8
SP1-40a	-	-	-	-	Seep	(a)	5	7.0	.125	5.4
SP1-41	-	-	-	-	Seep	(a)	2	7.0	Dry	-
SP1-42	-	-	-	-	1	3.3	<1	10.0	Dry	-
SP1-43	-	-	-	-	<1	3.3	1	7.0	Dry	-
SP1-44	-	-	-	-	3	12.0	5	7.0	Dry	-
SP1-45	-	-	-	-	-	-	-	-	<<1	6.1
SP1-46	-	-	-	-	-	-	-	-	<<1	9.0
SP1-47	-	-	-	-	-	-	-	-	<<1	6.8
SP1-48	-	-	-	-	-	-	-	-	.06	4.1
SP1-49	-	-	-	-	-	-	-	-	Seep	(a)
SP1-50	-	-	-	-	-	-	-	-	Seep	(a)
SP1-51	-	-	-	-	-	-	-	-	.06	7.9
SP1-52	-	-	-	-	-	-	-	-	Seep	(a)
SP1-53	-	-	-	-	-	-	-	-	.25	7.5
SP1-54	-	-	-	-	-	-	-	-	.25	4.9

Table 1. (continued)

Field Number	June 85 Flow (gpm)	June 85 Temp (°C)	Oct. 85 Flow (gpm)	Oct. 85 Temp (°C)	July 87 Flow (gpm)	July 87 Temp (°C)	Oct. 87 Flow (gpm)	Oct. 87 Temp (°C)	Oct. 89 Flow (gpm)	Oct. 89 Temp (°C)
SP2-1	-	-	-	-	4	5.0	Dry	-	1.5	10
SP2-2	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP2-3	-	-	-	-	5	14.0	Dry	-	<<1	5.5
SP2-4	-	-	-	-	10	6.0	Dry	-	Dry	-
SP2-5	-	-	-	-	2	5.0	Dry	-	Dry	-
SP2-6	-	-	-	-	5	5.0	Dry	-	Dry	-
SP2-7	-	-	-	-	4	6.0	Dry	-	Dry	-
SP2-8	-	-	-	-	Seep	(a)	Dry	-	Dry	-
SP2-9	-	-	-	-	5	5.0	1	4.0	.3	4.4
SP2-10	-	-	-	-	2	6.0	Dry	-	Dry	-
SP2-11	-	-	-	-	<<1	6.0	Dry	-	Dry	-
SP2-12	-	-	-	-	Seep	(a)	Dry	-	Dry	-
SP2-13	-	-	-	-	1	6.0	Dry	-	Dry	-
SP2-14	-	-	-	-	1	8.0	Dry	-	Dry	-
SP2-15	-	-	-	-	2	8.0	Dry	-	Dry	-
SP2-16	-	-	-	-	Seep	(a)	(c)	(c)	Dry	-
SP2-17	-	-	-	-	<<1	7.0	(c)	(c)	Dry	-
SP2-18	-	-	-	-	Seep	(a)	(c)	(c)	Dry	-
SP2-19	-	-	-	-	Seep	(a)	(c)	(c)	Dry	-
SP2-20	-	-	-	-	Seep	(a)	(c)	(c)	Dry	-
SP2-21	-	-	-	-	7	5.0	(c)	(c)	Dry	-
SP2-22	-	-	-	-	1	5.0	(c)	(c)	Dry	-
SP2-23	-	-	-	-	5	5.0	(c)	(c)	Dry	-
SP2-24	-	-	-	-	5	3.5	Seep	(a)	Dry	-

Table 1. (continued)

Field Number	June 85 Flow (gpm)	June 85 Temp (°C)	Oct. 85 Flow (gpm)	Oct. 85 Temp (°C)	July 87 Flow (gpm)	July 87 Temp (°C)	Oct. 87 Flow (gpm)	Oct. 87 Temp (°C)	Oct. 89 Flow (gpm)	Oct. 89 Temp (°C)
SP2-24a	-	-	-	-	-	-	-	-	Seep	(a)
SP2-25	-	-	-	-	Seep	(a)	Seep	(a)	Dry	-
SP2-26	-	-	-	-	Seep	(a)	Dry	-	Dry	-
SP2-27	-	-	-	-	4	3.0	1	4.0	.12	4.4
SP2-28	-	-	-	-	2	4.0	<1	4.0	.25	3.8
SP2-29	-	-	-	-	2	4.0	Dry	-	Seep	(a)
SP2-30	-	-	-	-	1	4.0	<<1	4.0	.5	1.1
SP2-31	-	-	-	-	2	6.0	Seep	(a)	Seep	(a)
SP2-32	-	-	-	-	2	4.0	<1	4.0	Seep	(a)
SP2-33	-	-	-	-	2	4.0	Dry	-	Seep	(a)
SP2-33a	-	-	-	-	4	4.0	1	5.0	.12	2.2
SP2-34	-	-	-	-	2	6.0	Dry	-	Dry	-
SP2-35	-	-	-	-	5	6.0	<1	5.0	0.1	.56
SP2-36	-	-	-	-	Seep	(a)	Dry	-	Dry	-
SP2-37	-	-	-	-	6	5.0	Dry	-	0.3	8.9
SP2-38	-	-	-	-	5	4.0	Dry	-	Seep	(a)
SP2-39	-	-	-	-	4	6.0	Dry	-	Dry	-
SP2-40	-	-	-	-	3	5.0	Dry	-	Dry	-
SP2-41	-	-	-	-	3	6.0	Seep	(a)	Seep	(a)
SP2-42	-	-	-	-	-	-	-	-	.25	3.06
SP2-43	-	-	-	-	-	-	-	-	Seep	(a)
SP2-44	-	-	-	-	-	-	-	-	Seep	(a)

(a) Insufficient water to sample
(b) Frozen
(c) Inaccessible due to weather and ground conditions

Table 2. Results of pH measurements for the period of June 1985 through October 1989 seep and spring survey in the coal lease and adjacent areas.

Field Number	June 85 pH (units)	Oct. 85 pH (units)	July 87 pH (units)	Oct. 87 pH (units)	Oct. 89 pH (units)
SP-7	8.36	-	-	-	-
SP-8	7.95	-	-	-	-
SP-9	(a)	-	-	-	-
SP-10	7.90	(a)	-	-	-
SP-11	(a)	-	-	-	-
SP-12	7.66	(a)	-	-	-
SP-13	8.57	-	-	-	(a)
SP-14	8.10	7.74	-	-	7.80
SP-43	(a)	-	-	-	-
SP-44	(a)	-	-	-	-
SP-45	(a)	-	-	-	-
SP-46	(a)	-	-	-	-
SP-47	(a)	-	-	-	-
SP-48	(a)	-	-	-	-
SP-49	(a)	-	-	-	-
SP-50	(a)	-	-	-	-
SP-51	(a)	-	-	-	-
SP-52	7.99	8.00	-	-	8.30
SP-53	7.31	7.95	-	-	-
SP-54	7.35	8.07	-	-	8.47
SP-55	7.36	7.59	-	-	(a)
SP-56	7.61	7.90	-	-	(a)

Table 2. (continued)

Field Number	June 85 pH (units)	Oct. 85 pH (units)	July 87 pH (units)	Oct. 87 pH (units)	Oct. 89 pH (units)
SP-57	7.35	7.56	-	-	-
SP-58	7.40	7.70	-	-	7.88
SP-59	7.43	7.86	-	-	-
SP-60	(a)	-	-	-	-
SP-61	7.36	8.16	-	-	-
SP-62	(a)	-	-	-	-
SP-63	(a)	-	-	-	-
SP-64	7.33	-	-	-	-
SP1-1	-	-	7.71	7.24	(a)
SP1-2	-	-	7.81	-	-
SP1-2a	-	-	7.80	7.97	8.68
SP1-3	-	-	7.61	7.61	7.70
SP1-4	-	-	(a)	(a)	-
SP1-5	-	-	(a)	(a)	-
SP1-6	-	-	(a)	(a)	-
SP1-7	-	-	(a)	(a)	-
SP1-8	-	-	7.54	-	7.99
SP1-9	-	-	(a)	(a)	(a)
SP1-10	-	-	(a)	(a)	-
SP1-10a	-	-	-	-	(c)
SP1-11	-	-	7.76	-	(c)
SP1-12	-	-	(a)	(a)	8.09
SP1-13	-	-	(a)	(a)	(a)

Table 2. (continued)

Field Number	June 85 pH (units)	Oct. 85 pH (units)	July 87 pH (units)	Oct. 87 pH (units)	Oct. 89 pH (units)
SP1-14	-	-	(a)	(a)	(a)
SP1-15	-	-	7.40	-	8.16
SP1-16	-	-	8.80	-	-
SP1-17	-	-	7.85	7.85	-
SP1-18	-	-	(a)	(a)	-
SP1-19	-	-	8.05	-	-
SP1-20	-	-	8.01	8.27	(c)
SP1-21	-	-	7.90	-	(c)
SP1-22	-	-	(a)	(a)	-
SP1-23	-	-	(a)	(a)	-
SP1-24	-	-	7.86	(a)	8.22
SP1-25	-	-	7.76	7.81	7.80
SP1-26	-	-	7.74	7.78	7.97
SP1-27	-	-	7.69	-	8.17
SP1-28	-	-	(a)	(a)	-
SP1-29	-	-	7.63	-	(a)
SP1-30	-	-	7.47	-	8.49
SP1-31	-	-	7.59	-	(a)
SP1-31a	-	-	-	-	(a)
SP1-32	-	-	(a)	(a)	-
SP1-33	-	-	(a)	8.27	7.03

Table 2. (continued

Field Number	June 85 pH (units)	Oct. 85 pH (units)	July 87 pH (units)	Oct. 87 pH (units)	Oct. 89 pH (units)
SP1-34	-	-	8.16	8.14	7.63
SP1-35	-	-	8.26	8.30	8.02
SP1-36	-	-	7.51	7.65	7.59
SP1-37	-	-	(a)	7.67	7.29
SP1-37a	-	-	7.42	7.56	7.13
SP1-38	-	-	7.29	7.24	7.22
SP1-39	-	-	8.17	7.48	6.69
SP1-40	-	-	7.17	7.17	7.27
SP1-40a	-	-	(a)	7.78	6.85
SP1-41	-	-	(a)	7.63	-
SP1-42	-	-	7.43	8.15	-
SP1-43	-	-	7.49	7.46	-
SP1-44	-	-	7.80	7.76	-
SP1-45	-	-	-	-	6.92
SP1-46	-	-	-	-	6.94
SP1-47	-	-	-	-	7.61
SP1-48	-	-	-	-	8.01
SP1-49	-	-	-	-	(a)
SP1-50	-	-	-	-	(a)
SP1-51	-	-	-	-	8.79
SP1-52	-	-	-	-	(a)
SP1-53	-	-	-	-	7.65
SP1-54	-	-	-	-	7.90

Table 2. (continued)

Field Number	June 85 pH (units)	Oct. 85 pH (units)	July 87 pH (units)	Oct. 87 pH (units)	Oct. 89 pH (units)
SP2-1	-	-	7.72	-	8.25
SP2-2	-	-	(a)	(a)	-
SP2-3	-	-	8.15	-	8.28
SP2-4	-	-	8.17	-	-
SP2-5	-	-	7.56	-	-
SP2-6	-	-	7.70	-	-
SP2-7	-	-	8.19	-	-
SP2-8	-	-	(a)	-	-
SP2-9	-	-	7.56	7.76	8.37
SP2-10	-	-	8.71	-	-
SP2-11	-	-	8.11	-	-
SP2-12	-	-	(a)	-	-
SP2-13	-	-	7.94	-	-
SP2-14	-	-	8.24	-	-
SP2-15	-	-	8.60	-	-
SP2-16	-	-	(a)	(b)	-
SP2-17	-	-	8.53	(b)	-
SP2-18	-	-	(a)	(b)	-
SP2-19	-	-	(a)	(b)	-
SP2-20	-	-	(a)	(b)	-
SP2-21	-	-	8.58	(b)	-
SP2-22	-	-	8.21	(b)	-
SP2-23	-	-	8.84	(b)	-
SP2-24	-	-	7.93	(a)	8.17

Table 2. (continued)

Field Number	June 85 pH (units)	Oct. 85 pH (units)	July 87 pH (units)	Oct. 87 pH (units)	Oct. 89 pH (units)
SP2-24a	-	-	-	-	(a)
SP2-25	-	-	(a)	(a)	-
SP2-26	-	-	(a)	-	-
SP2-27	-	-	7.46	7.60	8.02
SP2-28	-	-	7.78	8.01	8.36
SP2-29	-	-	7.57	-	(a)
SP2-30	-	-	8.01	8.05	8.41
SP2-31	-	-	7.73	(a)	(a)
SP2-32	-	-	7.56	8.28	(a)
SP2-33	-	-	7.85	-	(a)
SP2-33a	-	-	7.66	7.80	8.29
SP2-34	-	-	7.85	-	-
SP2-35	-	-	7.79	7.87	8.21
SP2-36	-	-	(a)	-	-
SP2-37	-	-	7.50	-	8.30
SP2-38	-	-	7.76	-	(a)
SP2-39	-	-	8.01	-	-
SP2-40	-	-	7.56	-	-
SP2-41	-	-	7.64	(a)	(a)
SP2-42	-	-	-	-	(a)
SP2-43	-	-	-	-	(a)
SP2-44	-	-	-	-	(a)

(a) Insufficient water to sample
(b) Inaccessible due to weather and ground conditions
(c) Frozen

Table 3. Results of specific conductance (umhos/cm @ 25° C) for the period of June 1985 through October 1989 seep and spring survey in the coal lease and adjacent areas.

Field Number	June 85 Specific Cond.	Oct. 85 Specific Cond.	July 87 Specific Cond.	Oct. 87 Specific Cond.	Oct. 89 Specific Cond.
SP-7	440	-	-	-	-
SP-8	280	-	-	-	-
SP-9	(a)	-	-	-	-
SP-10	220	(a)	-	-	-
SP-11	(a)	-	-	-	-
SP-12	250	(a)	-	-	-
SP-13	100	-	-	-	(a)
SP-14	150	340	-	-	380
SP-43	(a)	-	-	-	-
SP-44	(a)	-	-	-	-
SP-45	(a)	-	-	-	-
SP-46	(a)	-	-	-	-
SP-47	(a)	-	-	-	-
SP-48	(a)	-	-	-	-
SP-49	(a)	-	-	-	-
SP-50	(a)	-	-	-	-
SP-51	(a)	-	-	-	-
SP-52	600	540	-	-	392
SP-53	490	470	-	-	-
SP-54	500	500	-	-	352
SP-55	480	530	-	-	(a)
SP-56	490	470	-	-	(a)

Table 3. (continued)

Field Number	June 85 Specific Cond.	Oct. 85 Specific Cond.	July 87 Specific Cond.	Oct. 87 Specific Cond.	Oct. 89 Specific Cond.
SP-57	480	470	-	-	-
SP-58	500	500	-	-	470
SP-59	690	520	-	-	-
SP-60	(a)	-	-	-	-
SP-61	450	450	-	-	-
SP-62	(a)	-	-	-	-
SP-63	(a)	-	-	-	-
SP-64	440	-	-	-	-
SP1-1	-	-	360	440	(a)
SP1-2	-	-	280	-	-
SP1-2a	-	-	280	320	292
SP1-3	-	-	190	250	280
SP1-4	-	-	(a)	(a)	-
SP1-5	-	-	(a)	(a)	-
SP1-6	-	-	(a)	(a)	-
SP1-7	-	-	(a)	(a)	-
SP1-8	-	-	420	-	282
SP1-9	-	-	(a)	(a)	(a)
SP1-10	-	-	(a)	(a)	-
SP1-10a	-	-	-	-	(b)
SP1-11	-	-	360	-	(b)
SP1-12	-	-	(a)	(a)	340
SP1-13	-	-	(a)	(a)	(a)

Table 3. (continued)

Field Number	June 85 Specific Cond.	Oct. 85 Specific Cond.	July 87 Specific Cond.	Oct. 87 Specific Cond.	Oct. 89 Specific Cond.
SP1-14	-	-	(a)	(a)	(a)
SP1-15	-	-	380	-	326
SP1-16	-	-	280	-	-
SP1-17	-	-	390	410	-
SP1-18	-	-	(a)	(a)	-
SP1-19	-	-	400	-	-
SP1-20	-	-	360	350	(b)
SP1-21	-	-	370	-	(b)
SP1-22	-	-	(a)	(a)	-
SP1-23	-	-	(a)	(a)	-
SP1-24	-	-	310	(a)	389
SP1-25	-	-	490	330	294
SP1-26	-	-	430	340	282
SP1-27	-	-	450	-	282
SP1-28	-	-	(a)	(a)	-
SP1-29	-	-	470	-	(a)
SP1-30	-	-	440	-	992
SP1-31	-	-	430	-	(a)
SP1-31a	-	-	-	-	(a)
SP1-32	-	-	(a)	(a)	-
SP1-33	-	-	(a)	390	410

Table 3. (continued)

Field Number	June 85 Specific Cond.	Oct. 85 Specific Cond.	July 87 Specific Cond.	Oct. 87 Specific Cond.	Oct. 89 Specific Cond.
SP1-34	-	-	480	460	550
SP1-35	-	-	470	480	375
SP1-36	-	-	490	500	390
SP1-37	-	-	(a)	450	325
SP1-37a	-	-	500	490	363
SP1-38	-	-	480	470	360
SP1-39	-	-	460	450	360
SP1-40	-	-	530	690	310
SP1-40a	-	-	(a)	490	350
SP1-41	-	-	(a)	450	-
SP1-42	-	-	490	420	-
SP1-43	-	-	470	460	-
SP1-44	-	-	490	480	-
SP1-45	-	-	-	-	315
SP1-46	-	-	-	-	340
SP1-47	-	-	-	-	305
SP1-48	-	-	-	-	380
SP1-49	-	-	-	-	(a)
SP1-50	-	-	-	-	(a)
SP1-51	-	-	-	-	350
SP1-52	-	-	-	-	(a)
SP1-53	-	-	-	-	310
SP1-54	-	-	-	-	642

Table 3. (continued)

Field Number	June 85 Specific Cond.	Oct. 85 Specific Cond.	July 87 Specific Cond.	Oct. 87 Specific Cond.	Oct. 89 Specific Cond.
SP2-1	-	-	430	-	474
SP2-2	-	-	(a)	(a)	-
SP2-3	-	-	380	-	458
SP2-4	-	-	400	-	-
SP2-5	-	-	410	-	-
SP2-6	-	-	410	-	-
SP2-7	-	-	410	-	-
SP2-8	-	-	(a)	-	-
SP2-9	-	-	250	270	234
SP2-10	-	-	300	-	-
SP2-11	-	-	270	-	-
SP2-12	-	-	(a)	-	-
SP2-13	-	-	230	-	-
SP2-14	-	-	200	-	-
SP2-15	-	-	210	-	-
SP2-16	-	-	(a)	(c)	-
SP2-17	-	-	210	(c)	-
SP2-18	-	-	(a)	(c)	-
SP2-19	-	-	(a)	(c)	-
SP2-20	-	-	(a)	(c)	-
SP2-21	-	-	320	(c)	-
SP2-22	-	-	350	(c)	-
SP2-23	-	-	290	(c)	-
SP2-24	-	-	310	(a)	360

Table 3. (continued)

Field Number	June 85 Specific Cond.	Oct. 85 Specific Cond.	July 87 Specific Cond.	Oct. 87 Specific Cond.	Oct. 89 Specific Cond.
SP2-24a	-	-	-	-	(a)
SP2-25	-	-	(a)	(a)	-
SP2-26	-	-	(a)	-	-
SP2-27	-	-	440	380	410
SP2-28	-	-	400	380	328
SP2-29	-	-	410	-	(a)
SP2-30	-	-	370	380	413
SP2-31	-	-	390	(a)	(a)
SP2-32	-	-	410	350	(a)
SP2-33	-	-	410	-	(a)
SP2-33a	-	-	450	430	421
SP2-34	-	-	320	-	-
SP2-35	-	-	360	340	350
SP2-36	-	-	(a)	-	-
SP2-37	-	-	390	-	377
SP2-38	-	-	410	-	-
SP2-39	-	-	370	-	-
SP2-40	-	-	440	-	(a)
SP2-41	-	-	440	(a)	(a)
SP2-42	-	-	-	-	421
SP2-43	-	-	-	-	(a)
SP2-44	-	-	-	-	(a)

(a) Insufficient water to sample
(b) Frozen
(c) Inaccessible due to weather and ground conditions

Table 4. Geology and use of springs in the coal lease and adjacent areas.

Field Number	Geology	Use
SP-7	From snow patch at top of Castlegate SS.	Wildlife
SP-8	From snow patch at top of Castlegate SS.	Wildlife
SP-9	From sandstone/shale interface Castlegate SS/Blackhawk Fm.	None
SP-10	From snow patch at base of Castlegate SS.	Wildlife
SP-11	From colluvium over sandstone of Castlegate SS.	None
SP-12	From base of sandstone (Price River Fm.) in channel bottom.	Wildlife
SP-13	From sandstone at head of slide in Price River Fm.	Wildlife
SP-14	From fractured sandstone and soil in Price River Fm.	Wildlife
SP-43	From colluvium over sandstone in Blackhawk Fm.	None
SP-44	From colluvium over sandstone in Blackhawk Fm.	None
SP-45	From colluvium over sandstone in Blackhawk Fm.	None
SP-46	From sandstone bedding plane in Castlegate SS.	None
SP-47	From sandstone bedding plane in Castlegate SS.	None
SP-48	From colluvium over sandstone in Blackhawk Fm.	None

Table 4. (Continued).

Field Number	Geology	Use
SP-49	From sandstone bedding plane in road cut in Blackhawk Fm.	None
SP-50	From sandstone/shale interface in slump in Blackhawk Fm.	None
SP-51	From sandstone/shale interface in slump in Blackhawk Fm.	None
SP-52	From colluvium over sandstone in Blackhawk Fm., w/travertine.	Wildlife
SP-53	From fractured sandstone with travertine in Blackhawk Fm.	Wildlife
SP-54	From fractured sandstone with travertine in Blackhawk Fm.	Wildlife
SP-55	From fractured sandstone with travertine in Blackhawk Fm.	Wildlife
SP-56	From fractured sandstone with travertine in Blackhawk Fm.	Wildlife
SP-57	From fractured sandstone with travertine in Blackhawk Fm.	Wildlife
SP-58	From fractured sandstone in Blackhawk Fm.	Wildlife
SP-59	From colluvium over sandstone in Blackhawk Fm.	Wildlife
SP-60	From sandstone bedding plane in Castlegate SS.	None
SP-61	From fractured sandstone in Price River Fm.	Wildlife
SP-62	From sandstone/shale interface in Price River Fm.	None
SP-63	From sandstone/shale interface in Price River Fm.	None

Table 4. (Continued).

Field Number	Geology	Use
SP-64	From fractured sandstone in Price River Fm.	Wildlife
SP1-1	Alluvium on valley floor	Wildlife
SP1-2	Alluvium on valley floor	Developed
SP1-2a	Alluvium on valley floor	Wildlife
SP1-3	From fractured sandstone in Price River Fm.	Developed
SP1-4	From fractured sandstone in Price River Fm.	Wildlife
SP1-5	From fractured sandstone in Price River Fm.	Wildlife
SP1-6	From fractured sandstone in Price River Fm.	Wildlife
SP1-7	From fractured sandstone in Price River Fm.	Wildlife
SP1-8	From fractured limestone in North Horn Fm.	Wildlife
SP1-9	From fractured limestone in North Horn Fm.	Wildlife
SP1-10	Contact between North Horn and Price River Fms.	Wildlife
SP1-10a	Contact between North Horn and Price River Fms.	Wildlife
SP1-11	From fractured limestone in North Horn Fm.	Developed
SP1-12	From fractured limestone in North Horn Fm.	Wildlife
SP1-13	From fractured limestone in North Horn Fm.	Wildlife

Table 4. (Continued).

Field Number	Geology	Use
SP1-14	From fractured limestone in North Horn Fm.	Wildlife
SP1-15	From fractured limestone in North Horn Fm.	Wildlife
SP1-16	From fractured limestone in North Horn Fm.	Wildlife
SP1-17	From fractured limestone in North Horn Fm.	Wildlife
SP1-18	From fractured limestone in North Horn Fm.	Wildlife
SP1-19	From fractured limestone in North Horn Fm.	Wildlife Livestock
SP1-20	From fractured limestone in North Horn Fm.	Wildlife Livestock
SP1-21	From fractured limestone in North Horn Fm.	Wildlife Livestock
SP1-22	From fractured limestone in North Horn Fm.	Wildlife
SP1-23	From fractured limestone in North Horn Fm.	Wildlife
SP1-24	From fractured limestone in North Horn Fm.	Wildlife Livestock
SP1-25	From fractured limestone in North Horn Fm.	Wildlife
SP1-26	From fractured limestone in North Horn Fm.	Wildlife
SP1-27	From fractured limestone in North Horn Fm.	Wildlife
SP1-28	From fractured limestone in North Horn Fm.	Wildlife

Table 4. (Continued).

Field Number	Geology	Use
SP1-29	From fractured limestone in North Horn Fm.	Wildlife
SP1-30	From fractured limestone in North Horn Fm.	Wildlife
SP1-31	From fractured limestone in North Horn Fm.	Wildlife
SP1-31a	From fractured limestone in North Horn Fm.	Wildlife
SP1-32	From fractured sandstone in Price River Fm.	Wildlife
SP1-33	From alluvium in valley floor deposits.	Wildlife
SP1-34	From alluvium in valley floor deposits.	Wildlife
SP1-35	From alluvium in valley floor deposits.	Wildlife
SP1-36	From alluvium in valley floor deposits.	Wildlife
SP1-37	From alluvium in valley floor deposits.	Wildlife
SP1-37a	From alluvium in valley floor deposits.	Wildlife
SP1-38	From alluvium in valley floor deposits.	Wildlife
SP1-39	From alluvium in valley floor deposits.	Wildlife
SP1-40	From alluvium in valley floor deposits.	Wildlife
SP1-40a	From alluvium in valley floor deposits.	Wildlife

Table 4. (Continued).

Field Number	Geology	Use
SP1-41	From alluvium in valley floor deposits.	Wildlife
SP1-42	From alluvium in valley floor deposits.	Wildlife
SP1-43	From alluvium in valley floor deposits.	Wildlife
SP1-44	From alluvium in valley floor deposits.	Wildlife
SP1-45	From alluvium in valley floor deposits.	Wildlife
SP1-46	From alluvium in valley floor deposits.	Wildlife
SP1-47	From alluvium in valley floor deposits.	Wildlife
SP1-48	From fractured sandstone in Price River Fm.	Wildlife
SP1-49	From fractured sandstone in Price River Fm.	Wildlife
SP1-50	From fractured sandstone in Price River Fm.	Wildlife
SP1-51	From fractured sandstone in Price River Fm.	Wildlife
SP1-52	From fractured sandstone in Price River Fm.	Wildlife
SP1-53	From alluvium in valley floor deposits.	Wildlife
SP1-54	From fractured sandstone in Price River Fm.	Wildlife
SP2-1	From fractured limestone in North Horn Fm.	Wildlife

Table 4. (Continued).

Field Number	Geology	Use
SP2-2	Bottom of channel over limestone (North Horn Fm.)	None
SP2-3	Colluvium over limestone from 200' x 150' area.	Wildlife
SP2-4	From fractured limestone in North Horn Fm.	Wildlife
SP2-5	From fractured limestone in North Horn Fm. w/travertine.	Wildlife
SP2-6	From fractured limestone in North Horn Fm.	Wildlife
SP2-7	From fractured limestone in North Horn Fm.	Wildlife
SP2-8	Bottom of channel over limestone (North Horn Fm.).	None
SP2-9	From fractured limestone in North Horn Fm.	Developed
SP2-10	From fractured limestone in North Horn Fm.	Wildlife
SP2-11	Head of slump in ss/sh in Price River Fm.	None
SP2-12	Colluvium/sandstone in Price River Fm.	None
SP2-13	From fractured sandstone in Price River Fm.	Wildlife
SP2-14	From fractured limestone in Price River Fm.	Wildlife
SP2-15	From fractured sandstone in Price River Fm.	Wildlife
SP2-16	From sandstone/shale interface in Price River Fm.	None

Table 4. (Continued).

Field Number	Geology	Use
SP2-17	From fractured limestone in Price River Fm.	Wildlife
SP2-18	From fractured sandstone in Price River Fm. (Diffuse)	None
SP2-19	Colluvium/Alluvium adjacent to channel.	None
SP2-20	Colluvium/alluvium adjacent to channel.	None
SP2-21	From fractured limestone in Price River Fm.	Wildlife
SP2-22	From fractured limestone at head of slump in the Price River Fm.	None
SP2-23	From fractured limestone Price River Fm.	Wildlife
SP2-24	From fractured sandstone in Price River Fm.	Wildlife
SP2-24a	From fractured sandstone in Price River Fm.	Wildlife
SP2-25	From colluvium over limestone in North Horn Fm.	None
SP2-26	Sandstone over shale at head of small slump in North Horn Fm.	None
SP2-27	Colluvium in channel bottom in Price River Fm.	Developed
SP2-28	Sandstone/shale interface in Price River Fm.	Wildlife
SP2-29	From fractured sandstone in Price River Fm.	Wildlife
SP2-30	Fractured sandstone/shale interface in Price River Fm.	Wildlife

Table 4. (Continued).

Field Number	Geology	Use
SP2-31	Fractured sandstone/shale interface in Price River Fm.	Wildlife
SP2-32	Fractured sandstone/shale interface in Price River Fm.	Wildlife
SP2-33	Fractured sandstone/shale interface in Price River Fm.	Wildlife
SP2-33a	Fractured sandstone in the Price River Fm.	Wildlife
SP2-34	Fractured sandstone/shale interface in Price River Fm.	Wildlife
SP2-35	Fractured sandstone/shale interface in Price River Fm.	Wildlife
SP2-36	Fractured limestone swale in North Horn Fm.	Wildlife
SP2-37	From fractured limestone in North Horn Fm.	Wildlife
SP2-38	From fractured limestone in North Horn Fm.	Wildlife
SP2-39	From fractured limestone in North Horn Fm.	Wildlife
SP2-40	From fractured limestone in North Horn Fm.	Wildlife Livestock
SP2-41	From fractured limestone in North Horn Fm.	Wildlife
SP2-42	Fractured sandstone in the Price River Fm.	Wildlife
SP2-43	Fractured sandstone in the Price River Fm.	Wildlife
SP2-44	Fractured sandstone in the Price River Fm.	Wildlife

As indicated by the data presented in Table 4, approximately one third of the inventoried seeps and springs issue from the North Horn Formation. An additional one-fourth of the sources issue each from the Price River Formation and from colluvial/alluvial deposits. The remaining seeps and springs were found issuing in approximately equal numbers from the Castlegate Sandstone and the Blackhawk Formation.

Approximately 60 percent of all the seeps and springs found during the early-season inventories had flows of one gallon per minute or less. These flows typically decreased by the time of the late-season inventories, with most of the low-flow sources issuing only as seeps or being dry.

Notable exceptions to the decreasing-flow generality occurred at those springs issuing from alluvium in the bottom of Little Joes Valley near Indian Creek. Flows in these springs all increased substantially between the July 1987 and October 1987 surveys. In addition, much of the valley floor east of the creek became noticeably wetter during the intervening period.

A review of local geologic conditions suggests that two sources of recharge affect the flow of springs near Indian Creek but do not influence other springs in the study area. First, groundwater in the shallow alluvium and colluvium on the west-facing side of East Mountain flows downhill toward the valley and discharges into the valley alluvium. The arrival of this water later in the season is due to the lag time as snowmelt-derived groundwater flows through the soil toward the valley.

Secondly, springs adjacent to Indian Creek appear to be associated with the Joes Valley Fault. Discharge from this fault is likely also affected by the delayed recharge from the mountain.

Less than 10 percent of the seeps and springs found within the study area issue from the regional coal-bearing formation (the Blackhawk Formation). Of the sources found issuing from the Blackhawk Formation, one-third issued as seeps in June 1985 (but were dry in October 1985) while the remaining two-thirds issued at rates in excess of five gallons per minute.

Seeps and low-flow springs issuing from the Blackhawk Formation typically occur at the interface between overlying sandstone lenses and less-permeable underlying shale layers. The low seepage rates are the result of the low hydraulic conductivity of the Blackhawk Formation in its unfractured state. Laboratory permeability data provided by Lines (1985) from a core collected approximately 10 miles south of the coal lease area indicate that sandstone units of the Blackhawk Formation have an average horizontal hydraulic conductivity of only 1.3×10^{-2} foot per day and an average vertical hydraulic conductivity of only 3.8×10^{-3} foot per day. Shales and siltstones within the Blackhawk Formation were found to have maximum horizontal and vertical hydraulic conductivities of 1.0×10^{-7} and 1.2×10^{-8} foot per day, respectively. These values, which are typical of unfractured sandstone and shale (Freeze and Cherry, 1979), indicate that the units are not conducive to rapid water movement.

The relatively low hydraulic conductivity of the shale units within the Blackhawk Formation compared with the sandstone units limits the downward movement of groundwater through the unfractured portions of the formation. Thus, as water recharges the Blackhawk Formation (either through snowmelt or rainfall directly onto the formation or through subsurface seepage from an overlying formation) it is forced to flow horizontally to the surface upon encountering a siltstone or shale layer. This creates locally perched groundwater conditions, with the recharge area for seeps and small springs with the Blackhawk being restricted in size.

Notable exceptions to the above generality concerning the Blackhawk Formation occur at the remainder of the study-area Blackhawk springs (SP-53 through SP-58 located in Crandall Canyon). These springs discharged from fractured sandstone at rates of 5 to 15 gallons per minute during both the early- and late-season inventories. Travertine deposits are common at these springs, suggesting that the recharge area for these springs is dominated by limestone (probably the North Horn Formation and the Price River Formation on East Mountain). The fractured Blackhawk Formation, therefore, probably serves more as a conveyance medium rather than a significant source of water to the springs.

3.3 Usage of Springs

Usage of springs issuing from the North Horn Formation tends to be high, with both wildlife and domestic stock utilizing the water. Since the upper elevations of East Mountain are heavily utilized by sheep in the summer months, many of the springs have been developed with troughs to provide a more stable water supply.

Springs issuing from the Price River Formation showed signs of significant use by wildlife but lesser usage by domestic stock. Slopes in the outcrop areas of this formation are steeper than in areas overlain by the North Horn Formation, thus accounting for the lower usage by domestic stock.

Usage of water issuing from the Castlegate Sandstone and the Blackhawk Formation is limited except in the bottom of Crandall Canyon (due primarily to inaccessibility and low flow rates). Those springs issuing from the fractured Blackhawk Formation in the bottom of Crandall Canyon (SP-53 through SP-58) showed signs of wildlife use. No signs of domestic stock usage were noted at springs issuing from the Castlegate Sandstone or the Blackhawk Formation.

3.4 Field Water-Quality Results

Results of the field water-quality measurements are summarized in Figure 4. Specific conductance was typically lowest and pH highest in springs issuing from the North Horn and Price River Formations. These phenomena occur due to the generally higher topographic position and higher lime content of the formations, respectively.

Average temperatures in the springs varied only about 2° C throughout the area, with averages being slightly less in springs issuing from the North Horn and Price River Formations. This may result from the probable shallow nature of springs issuing from the Blackhawk Formation and the alluvial/colluvial materials (thus increasing water temperatures).

3.5 Laboratory Water-Quality Results

Water-quality samples were collected for laboratory analyses from selected springs within the survey boundary area. The springs selected for analyses are those springs which are identified on the published USGS topographic maps. These springs were identified in the field (Figure 3) by EarthFax as:

- SP 58
- SP1-3
- SP1-25
- SP2-9
- SP2-33a

The laboratory analyses provide data concerning the major cations and anions, metals and nutrient content of the water issuing from the springs. The results of the laboratory analyses are presented in Appendix A.

The data indicate that the water issuing from the springs is markedly different between springs. However, the overall groundwater quality is considered good for all the springs sampled. The water issuing from the fractured Blackhawk Formation possess

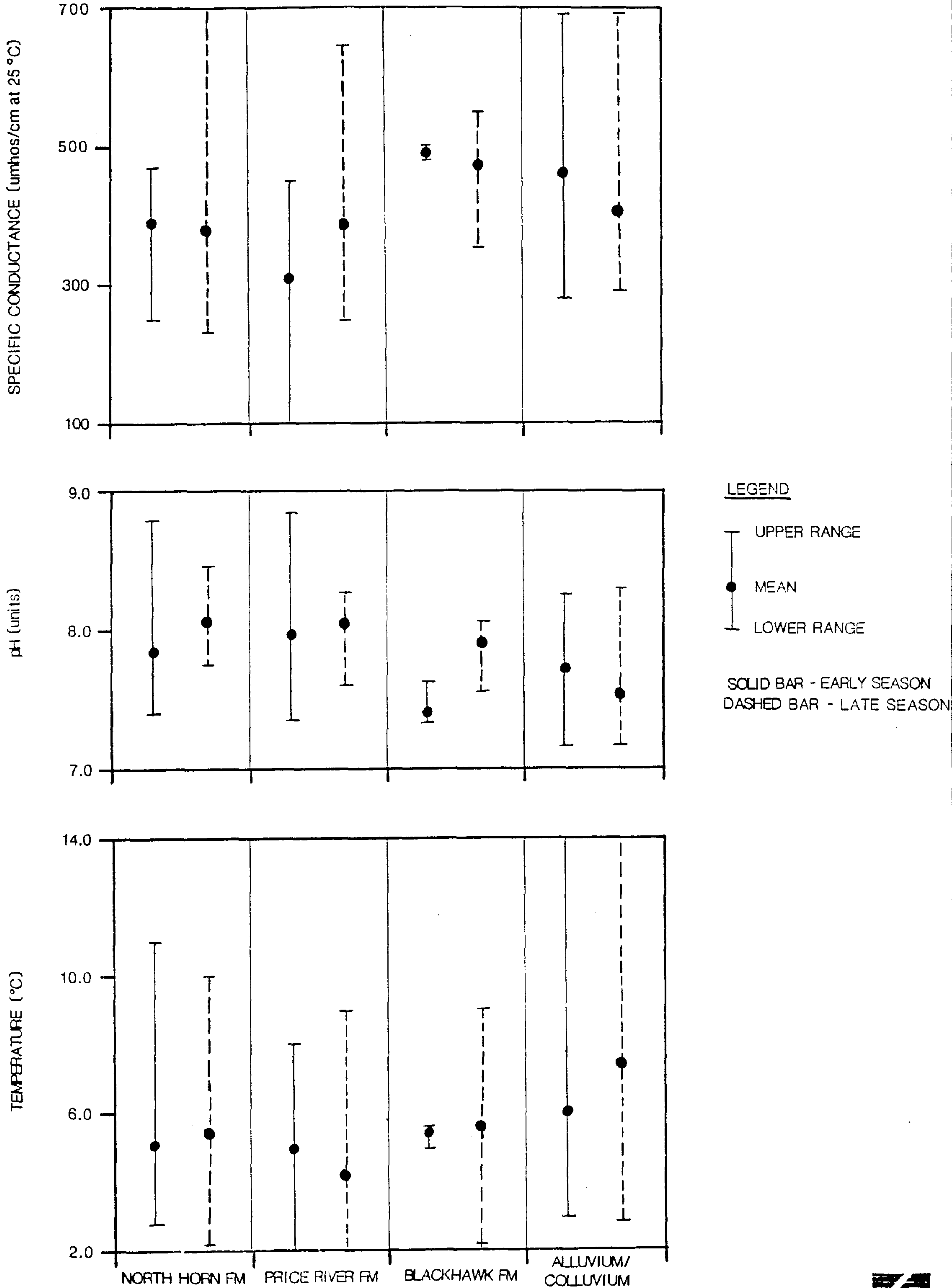

FIGURE 4 - FIELD WATER-QUALITY SUMMARY

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slightly higher values for pH, total dissolved solids and electrical conductivity. Whereas, the Price River Formation has the lowest values for pH, total dissolved solids and electrical conductivity.

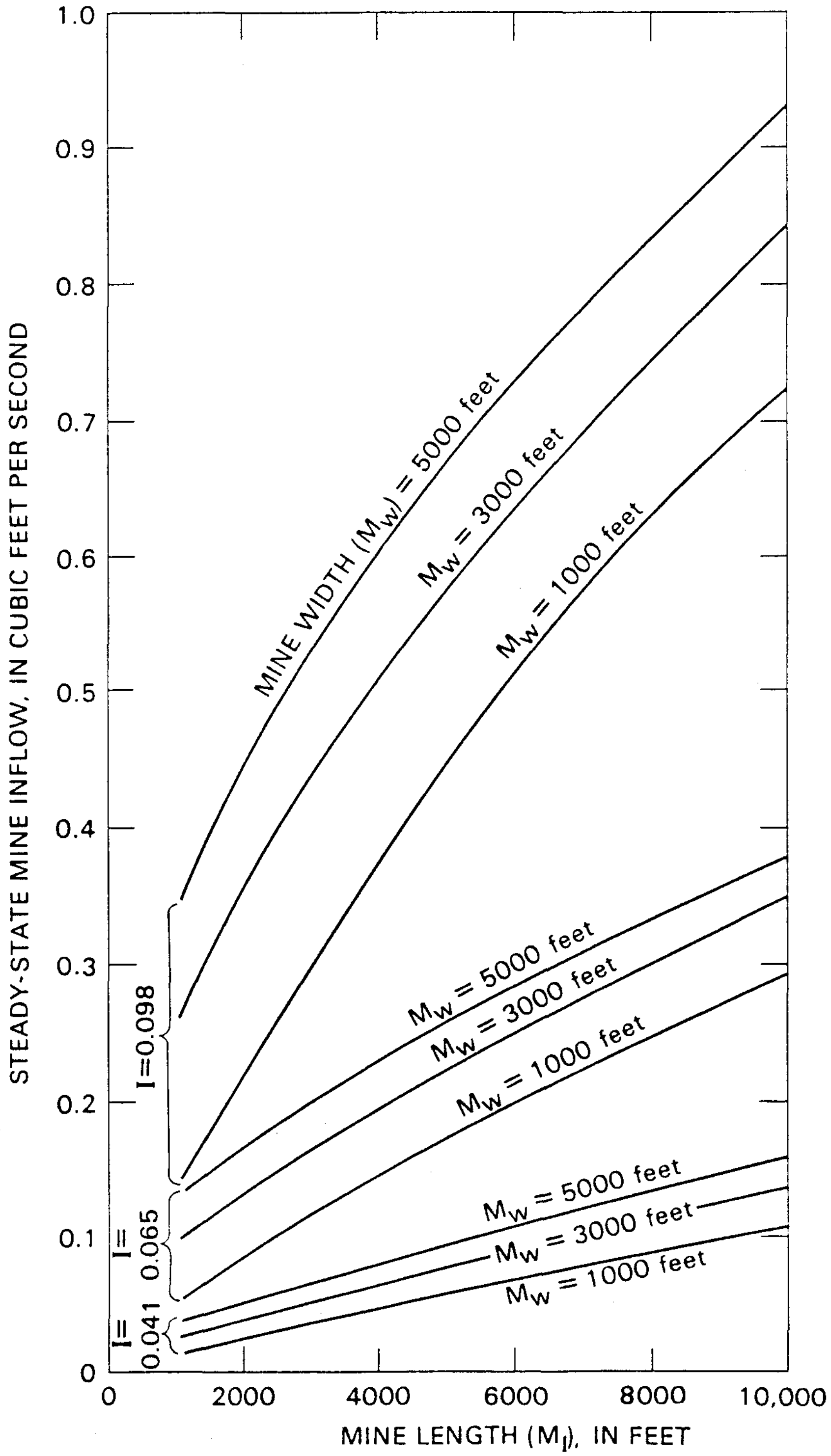
3.6 Potential Impacts of Mining

The primary potential for impacts to the groundwater system from mining will occur from mine dewatering (resulting in removal of water from the aquifers) and subsidence (resulting in physical alteration of the aquifers). Although these impacts cannot be quantified until a mine plan is developed, a general discussion of the potential for impacts can be provided.

Due to the topographic location of the coal lease areas, it is assumed that all the mine workings within the lease areas will be in the saturated portion of the Blackhawk Formation. Thus, groundwater inflow to the mine workings can be expected. Based on modeling results presented by Lines (1985) for the Trail Mountain area (approximately 10 miles south of the NEICO coal lease areas), potential inflow rates to the workings are presented in Figure 5. Assuming that the hydraulic gradient in the Blackhawk-Star Point aquifer beneath East Mountain is similar to that beneath Trail Mountain as reported by Lines (1985), a hydraulic gradient (I) of 0.065 can be used for Figure 5.

According to Figure 5, if the mine width is 1000 feet and the mine length is 5000 feet, a steady-state inflow of approximately 0.17 cubic feet per second (76 gallons per minute) can be expected. Alternatively, if the mine is 5000 feet wide and 10,000 feet long, an inflow of about 0.38 cubic feet per second (170 gallons per minute) can be expected. Dewatering may affect the flow of springs SP-52 through SP-58 but should not directly affect other springs in the study area since the remaining springs appear to be perched, with no direct hydraulic connection to the potential mine workings. Effects can be better quantified after the mine workings have been designed.

Subsidence is the fracturing or downwarping of overburden that occurs when coal is removed. Fractures that result from subsidence can extend several hundred feet upward through overlying perching beds. If this was to occur, water in the perched aquifer would be diverted downward, thus decreasing discharges at springs fed by the perched aquifer. Some of this diverted water could also flow sufficiently downward to intercept the mine workings, thus increasing discharges from the mine.



SOURCE: LINES (1985)

FIGURE 5 - PROJECTED INFLOW TO MINE WORKINGS

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Lines (1985) points out that, due to similarities in water quality between the various formations, adverse impacts to water quality would probably not result from subsidence effects. The quality of water in the Blackhawk-Star Point aquifer could increase slightly if the enhanced permeability of the formation created by subsidence fractured increased groundwater flow rates through the aquifer and decreased the time of contact between rock and water.

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